The Dilemma and Relief Path of Digitally Enabling the High-Quality Development of the Sports Industry

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Abstract: Under the dual drive of the digital economy and the strategy of a strong sports nation, digital technology has become the core kinetic energy to reconstruct the ecology of the sports industry. This paper analyzes the practical picture and practical difficulties in the digital transformation of China's sports industry through literature research, case study analysis, and policy text interpretation. It is found that intelligent manufacturing, VR viewing and big data management have formed the whole chain innovation of production-consumption-management, but they are faced with outstanding problems such as core technology dependence, data silos and insufficient industrial synergy. To solve these problems, it is necessary to build a synergistic ecosystem of "technological breakthrough, industrial synergy and policy guarantee", focusing on the promotion of domestic substitution of motion sensors, the construction of sports data exchanges, and the cultivation of composite talents. This study provides theoretical references for cracking the "necklace" problem of digital transformation of the sports industry and provides actionable solutions for policymakers and business practitioners.

Keywords: Digital Empowerment; Sports Industry; High-Quality Development; Technological Dilemma; Synergistic Ecology

1. Introductory

The world is experiencing the fourth industrial revolution represented by artificial intelligence, blockchain, and meta-universe, and the digital transformation of the sports industry, as a new growth pole of the national economy, has become an irreversible trend [1]. According to Statista data, the global digital sports market reached $215 billion in 2023, with an annual growth rate remaining high at 12.8%. China's "14th Five-Year Plan" sports development plan [2] clearly puts forward the strategic goal of "by 2025, the total size of the sports industry exceeded 5 trillion yuan, and the digital economy has become the core driving force". However, in practice, technology hollowing out, data governance disorder, and other issues seriously constrain the transformation process. Existing research focuses on the surface effect of technology application [3], and there is a lack of exploration of the deeper mechanisms and institutional barriers to systemic change in the industry. This paper innovatively constructs a three-dimensional analysis framework of "technology-industry-policy", and by deconstructing the practical logic and obstacles of the digitally-enabled sports industry, it proposes a transformation path with Chinese characteristics to provide a new paradigm for the high-quality development of the sports industry.

2. Practical Picture and Core Value of Digitally Empowered Sports Industry

2.1 Digital Technology Reshapes the Ecology of The Sports Industry

First, the production side: intelligent manufacturing promotes the upgrading of sports equipment. the application of intelligent manufacturing technology is promoting the continuous upgrading of sports equipment, bringing athletes and sports enthusiasts better quality and smarter products. For example, Li-Ning has launched 3D printed running shoes, which utilize 3D printing technology to accurately manufacture ergonomic sole structures that can provide optimal support and cushioning effects according to the runner's foot shape and sports habits, effectively enhancing running efficiency and reducing sports injuries. Meanwhile, the research and development of intelligent sports equipment is also advancing, such as intelligent fitness

equipment that can monitor real-time exercise data, including exercise intensity, exercise time, calories consumed, etc., and provide users with personalized training recommendations through data analysis to help users better achieve their fitness goals.

Second, the consumer side: virtual reality (VR) live events, sports health APP reconstruction of the user experience. the ecology of the sports industry at the consumer side has also undergone profound changes empowered by digital technology, and VR live streaming and sports health apps have become important means of reconstructing the user experience. VR live streaming of events creates an immersive viewing environment, allowing the audience to feel as if they were in the scene of the game, and watch the game from all angles, which greatly enhances the interest and sense of reality of watching the game. For example, in some large-scale sports events, the audience can watch the game through VR equipment to feel the warm atmosphere and intense and exciting competition scene. In addition, sports and health APPs such as Keep and Gudong are also popular among users. These APPs not only provide a wealth of exercise courses and training programs to meet the needs of different users, but also record the user's exercise data, analyze the effect of exercise, and provide users with professional health advice and social interaction platforms, so that users can better manage their health and sports life.

Third, the management side: Big data optimizes the operation of the stadium [4]. Big data technology is widely used in the operation and management of sports venues through the collection and analysis of venue operation data to achieve the optimal allocation of resources and improve operational efficiency. For example, the “Bird's Nest” National Stadium, through the introduction of intelligent management system, the use of big data technology for real-time monitoring and analysis of the venue's energy consumption, personnel movement, facility use, etc., to formulate a scientific and reasonable management strategy, and successfully reduced the energy consumption by 30%, which not only saves the operating costs, but also reduces the impact on the environment, and achieves sustainable development. This saves operating costs, reduces the impact on the environment, and realizes sustainable development. In addition, big data can also help venue managers better understand the needs and preferences of spectators to optimize event arrangements and services and enhance the satisfaction and loyalty of spectators.

2.2 Core Value Embodiment of High-Quality Development

First, efficiency improvement: AI algorithms optimize athletes' training programs [5]. the application of AI algorithms in athletes' training has brought revolutionary changes to sports training. through the analysis of athletes' training data and performance, AI can tailor-made personalized training programs for athletes to effectively improve the training efficiency and competitive level. For example, the “AI Coach” system introduced by the national diving team can accurately analyze athletes' movements, capture every detail, and compare them with standard movements to find problems and deficiencies in a timely manner, to provide athletes with targeted suggestions for improvement and training guidance. This training method based on AI technology can not only help athletes master correct technical movements faster but also avoid sports injuries caused by incorrect movements, which greatly improves the training effect and athletes' competitive ability.

Secondly, attitude innovation: the rise of new tracks such as e-sports and digital fitness. the rapid development of digital technology has given rise to a series of new forms and tracks in the sports industry, injecting new vitality into the innovative development of the sports industry. Among them, e-sports and digital fitness are particularly prominent. As an emerging form of sports competition, eSports has attracted the attention and participation of many young users by virtue of its unique competitive charm and digitalized dissemination method. In 2023, the market size of eSports in China has exceeded 160 billion yuan, showing great market potential and development space. Digital fitness, on the other hand, combines virtual reality, augmented reality and other technologies to provide users with more diversified and interesting fitness methods, enabling people to do fitness workouts in virtual scenarios, breaking the time and space limitations of traditional fitness, meeting the needs of

different users, and promoting the innovative development of the fitness industry.

Third, inclusive growth: digital platforms break geographical restrictions and help rural sports resources to be inclusive. the rise of digital platforms has provided unprecedented convenience for the sharing and dissemination of sports resources, breaking geographical restrictions and enabling sports resources to more equitably benefit a wide range of areas, especially rural areas [6]. For example, short-video platforms such as Jittery Voice have attracted hundreds of millions of views through live broadcasting of village sports events such as “Village BA”, which not only allows more people to understand the charm and vitality of village sports, but also provides broad attention and support for the development of village sports. This digital platform empowerment enables sports enthusiasts in rural areas to get more opportunities to show themselves and attracts more resources and attention into rural sports, promoting the prosperous development of rural sports, narrowing the gap between urban and rural sports development, and realizing the inclusive growth of the sports industry. As shown in **Figure 1**

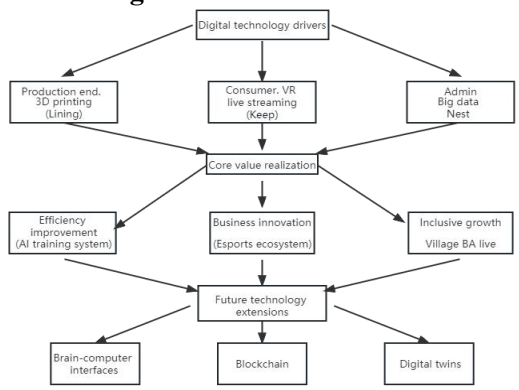

Figure 1. Practical Picture and Core Value of Digitally Enabled Sports Industry

3. The Realistic Dilemma of Digitally Enabling the High-Quality Development of the Sports Industry

3.1 Technical Level: Key Areas of The “Neck”

First, hardware dependence: high-end motion sensors and chips are still dependent on imports. In the process of digitally empowering the sports industry, China faces a more serious dependence on imports in the field of high-end hardware. For example, Huawei sports watch, as the leading intelligent sports equipment in China, the localization rate of its core component chip is less than 40%. This means that China is restricted in key technology areas such as high-end motion sensors and chips, which not only affects the further improvement of product performance and functionality but also may lead to an increase in product costs and instability in the supply chain. In addition, this hardware dependence may also limit the competitiveness of China's sports industry in the international market and hinder the development of China's sports industry in the direction of high-end and intelligentization.

Secondly, scene fragmentation: part of the technology application stays in the “display stage” and lacks in-depth integration with the industry. Part of the application of digital technology in the sports industry remains in the relatively primary stage of display and fails to realize the deep integration and wide application within the industry [7]. Taking VR viewing as an example, although VR technology has great potential in the live broadcasting of sports events and can provide an immersive viewing experience for the audience, its current popularity rate is less than 5%. This is mainly due to the high cost of technology, low penetration of equipment, and the complexity of content production. This phenomenon of scene fragmentation makes the application of digital technology in the sports industry limited and prevents it from giving full play to its role in promoting industrial upgrading and innovation, as well as making it difficult to meet the increasingly diversified and personalized sports consumption needs of consumers.

3.2 Data Level: Lagging Governance Capability

First, the risk of privacy leakage: excessive collection of user data by sports and health APPs. With the popularity of sports and health APPs, the privacy and security of user data has become increasingly prominent. Some APPs have excessive collection of user data, not only obtaining the necessary information related to sports and health, but also collecting a large amount of personal privacy data not related to sports, such as users' location information, social relationships, etc. [8]. 2022 A well-

known fitness platform was fined 2 million yuan in 2022 due to data leakage, which not only poses a privacy and security risk to the users but also causes serious damage to the company's reputation and user trust. This risk of privacy leakage may lead to a decline in user trust in sports and health APPs, affecting the apps' user stickiness and market share, and thus hindering the development of digital services in the sports industry.

Second, the silo effect: the lack of data sharing mechanism between sports enterprises and medical institutions and government departments. the data silo effect is a common problem in the sports industry. There is a lack of effective data sharing mechanisms between sports enterprises, medical institutions and government departments, resulting in data not being able to circulate and integrate between different subjects. For example, the sports data collected by sports enterprises cannot be combined with the health data of medical institutions, making it difficult for medical institutions to fully understand the sports and health status of users and unable to provide users with more accurate health advice and medical services. At the same time, when government departments formulate policies and plans for the sports industry, it is also difficult to make scientific decisions and implement precise measures due to the lack of support from enterprise data. This data silo effect limits the collaborative development and optimal allocation of resources in the sports industry, and affects the overall efficiency and innovation ability of the industry.

3.3 Industry Level: Insufficient Synergy

For one thing, small and medium-sized enterprises have difficulties in transformation: the digitalization investment ratio of traditional sports manufacturing enterprises is less than 10%. For many traditional sports manufacturing enterprises, digital transformation faces many difficulties and challenges. According to the data of China Sporting Goods Federation, the digitalization investment ratio of traditional sports manufacturing enterprises is less than 10%. This is mainly due to SMEs' limited capital, insufficient technical reserves, and talent shortages. Digital transformation requires enterprises to invest heavily in hardware equipment acquisition, software system development, talent training, etc., and SMEs often find it difficult to bear these costs. In addition, small and medium-sized enterprises in the process of digital transformation may also face technical application difficulties, transformation effect that is not obvious, and other issues, which further reduces the enthusiasm and initiative of its transformation. This transformation difficulty makes the competitiveness of traditional sports manufacturing enterprises in the digital era gradually weaken, and it is difficult to adapt to the market demand for intelligent and personalized sports products.

Secondly, the industry chain is split: the digitalization of event IP development and derivatives sales is not well connected. the sports industry covers a variety of links, such as event IP development and derivatives sales, but in the process of digital transformation, there is a split in the connection between these links. For example, in terms of event IP development, although many events have been broadcast live and promoted through digital means, the digital sales and marketing of event derivatives have failed to achieve effective convergence. the data sharing and synergistic cooperation between event organizers and derivatives producers and sellers are not close enough, resulting in the development and sale of derivatives not being able to make full use of the digital influence of event IP and making it difficult to maximize the overall value of the industry chain. This industry chain fragmentation not only affects the digital synergistic development of the sports industry but also may lead to the waste of resources and loss of efficiency among various links, restricting the high-quality development of the sports industry.

3.4 Policy and Talent Level: Weak Supporting Support

For one thing, there is a lack of standards: the construction of smart venues, e-sports rules, and other lack of uniform standards. In the development process of the digitally-enabled sports industry, the lack of standards is a problem that needs to be solved urgently. For example, in the construction of smart venues, there are no unified technical standards and specifications, resulting in different venues adopting different technical solutions and equipment in the process of intelligent

construction, making it difficult to realize interconnection and data sharing between venues. Similarly, in the field of e-sports, there is also a lack of unified standards and norms for competition rules, player training, tournament operation, etc., which makes the e-sports industry in the process of development in a certain state of confusion and disorder. This lack of standard not only increases the operation cost and market risk of enterprises, but also brings difficulties to the supervision and management of the industry, which is not conducive to the healthy and orderly development of the sports industry.

Secondly, there is a shortage of composite talents: the number of practitioners who know both sports operation and digital technology is less than 20% of the industry demand. the digital transformation of the sports industry requires many composite talents who know both sports operations and digital technology. However, there is currently a large gap in such composite talents, which is less than 20% of the industry's demand. This is mainly because the cross-disciplinary talent training system in the field of sports industry and digital technology has not yet been perfected, and there are deficiencies in the relevant professional settings and curriculum teaching in colleges and vocational schools, which makes it difficult for graduates to meet the actual needs of enterprises. At the same time, the training and incentive mechanism for composite talents in the industry is not sound enough, which makes the phenomenon of talent loss more serious. This shortage of composite talents seriously restricts the speed and quality of the digital transformation of the sports industry, affects the innovation ability and market competitiveness of enterprises, and becomes a major bottleneck in the high-quality development of the sports industry.

4. Relief Path: Building a Synergistic Ecology of Technology-Industry-Policy

4.1 Technological Breakthrough: Strengthening Independent Innovation and Scene Landing

First, attack the “neck” technology: set up a special fund for sports science and technology to support the research and development of sports biomechanical sensors and AI algorithms. In order to solve the “neck” problem of China's sports industry in key technology areas, it is necessary to set up a special sports science and technology fund. These funds will focus on supporting the research and development of sports biomechanical sensors and AI algorithms, aiming to enhance China's independent innovation ability in the field of high-end sports science and technology. For example, sports biomechanical sensors can accurately monitor athletes' movement posture, power distribution and other key data, providing strong support for scientific training and sports injury prevention, while AI algorithms can analyze a large amount of training data, customize personalized training programs for athletes, and improve the training effect and competitive level. Through the support of the special fund, more research institutions and enterprises will be attracted to invest in the research and development of these key areas, accelerating technological breakthroughs and innovations, reducing dependence on foreign technology, and promoting the development of China's sports industry in the direction of high-end and intelligent.

Second, to promote the “meta-universe+sports” scenarios: to create a virtual fitness community (such as Baidu “Xiyang” fitness space) and NFT digital sports collection. To keep up with the development trend of the digital era, we should vigorously promote the innovative application scenarios of “meta-universe+sports”. For example, to create a virtual fitness community, Baidu's “Xiyang” fitness space is a good example, where users can create personalized virtual images, join fitness courses with friends, or engage in virtual sports competitions, making fitness more interesting and social. In addition, the NFT Digital Sports Collection brings new opportunities to the sports industry. Each NFT digital sports collectible has a unique digital logo, which can be a limited-edition digital sneaker, a digitally signed photo of a famous athlete, etc. These collectibles not only have a collector's value but also bring unique digital experiences and rights to the holders, such as the priority to participate in offline activities, etc. By promoting these “meta-universes”, the NFT digital sports collectibles can bring new opportunities for the sports industry. By promoting the application scenarios of “Metaverse+Sports”, more young users can be

attracted to participate in sports activities, injecting new vitality and innovative elements into the sports industry and expanding the development boundary of the sports industry.

4.2 Industrial Synergy: Building a Cross-border Integration Ecosystem

First, the platform empowers small and medium-sized enterprises (SMEs): it supports Tencent, Ali and other Internet giants to open their digital middle platforms and reduce SMEs' transformation costs. To help SMEs overcome the financial and technical difficulties in the process of digital transformation, large Internet companies such as Tencent and Ali should be encouraged and supported to open their digital middle platforms. These digital platforms integrate a variety of advanced digital technology capabilities, such as cloud computing, big data analysis, artificial intelligence, etc. SMEs can access these platforms to quickly obtain the tools and services needed for digital operations, such as accurate market data analysis, efficient customer relationship management, etc., to reduce their digital transformation costs and thresholds. For example, a small sporting goods manufacturer, with the supply chain optimization services of Ali's digital middle office, can more accurately predict market demand, reasonably arrange production plans, improve inventory turnover, and reduce operating costs. At the same time, the Internet giant's open digital platform can also promote data sharing and business synergy between different enterprises, forming a good industrial ecology and promoting the digital upgrading and collaborative development of the entire sports industry.

Second, extend the digital industry chain: promote the digitization of the whole chain of “event IP, derivatives and cultural tourism”. the digital transformation of the sports industry is not only limited to live broadcasting and dissemination of events but should also be extended to the upstream and downstream of the industry chain to realize the digitization of the whole chain of “event IP - derivatives - culture and tourism” and other links. We can learn from the NBA's “League Pass” model to maximize the influence of tournament IP through digital means and drive the sales of derivatives and the development of the cultural tourism industry. For example, to create a comprehensive digital platform, users can not only watch live matches but also get discount coupons for derivatives on the platform and the right to purchase tickets for offline sports activities after purchasing digital products related to the event IP. At the same time, the platform can also integrate the resources of sports tourism and provide users with personalized sports tourism route recommendations and booking services. This whole-chain digitization approach can break the information barriers between various links, achieve data interconnection and resource optimization, enhance the synergy effect and commercial value of the entire sports industry chain, and provide users with a richer and more diverse sports consumption experience.

4.3 Data Governance: Equal Emphasis on Security and Value

First, establish a sports data exchange: using the Shanghai Data Exchange as a blueprint, promote the compliant circulation of training data and event copyrights. To realize the safety, compliant circulation, and value mining of sports data, a specialized sports data exchange should be established. the operation mode and rules of the Shanghai Data Exchange can be used as a blueprint, and a standardized and efficient sports data trading platform can be constructed by combining the characteristics and needs of the sports industry. On this platform, all kinds of sports data, such as athletes' training data, live broadcast data of events, event copyrights, etc., can be used as trading targets for legal and compliant transactions. For example, a professional sports data analysis company can purchase athletes' training data through the data exchange and, after in-depth analysis, provide athletes with more scientific training advice and athletic enhancement programs. At the same time, event organizers can also sell event rights to multiple media platforms through the data exchange to maximize the value of the rights. Through the establishment of a sports data exchange, it can promote the reasonable flow and sharing of sports data, stimulate the potential for innovative application of data, provide strong data support for the digital development of the sports industry, and at the same time protect the legitimate rights and interests of data providers and users.

Second, improve the privacy protection system:

promote the scenario-based landing of the Personal Information Protection Law in the sports field. In the process of digitization of the sports industry, the privacy protection of user data is crucial. To ensure the effective implementation of relevant laws and regulations, the scenario-based implementation of the Personal Information Protection Law in the sports field should be vigorously promoted. Sports enterprises and related organizations need to strengthen their attention to user data privacy and establish a sound privacy protection system and data security management mechanism. For example, when collecting user data, sports and health APPs should clearly inform users of the type of data collected, its use and protection measures, and obtain their explicit authorization. At the same time, APP operators need to adopt encrypted storage, access control, and other technical means to prevent user data from being leaked, tampered with, or misused. In addition, the regulatory authorities should also strengthen the supervision and inspection of data privacy protection in the sports sector, and penalize enterprises that collect, use and leak user data in violation of the law, to safeguard the legitimate rights and interests of users, enhance users' trust in sports digital products, and promote the healthy and sustainable development of the digitalization of the sports industry.

4.4 Policy Guarantee: Improve Top-Level Design and Talent Cultivation

First, formulate a special plan for digital sports: clarify the development roadmap for smart venues, eSports, and other segments. To guide and promote the digital transformation of the sports industry at the macro level, the government should formulate a special plan for digital sports. In the plan, it is necessary to clarify the development goals, key tasks and implementation paths of key segments such as smart venues and e-sports. For example, for the construction of smart venues, the plan should include standards for equipping venues with intelligent facilities, requirements for the construction of data management systems, and specific measures for improving event services and spectator experience to provide clear construction guidance for venue operators. In the field of e-sports, the plan should cover the improvement of the e-sports event system, the cultivation of e-sports talents, and the construction of e-sports industrial parks to promote the standardization and large-scale development of the e-sports industry. Through the formulation of such a special plan, it can integrate the resources of all parties, form policy synergy, and ensure that the digital transformation of the sports industry will be orderly promoted in each segment to realize the overall high-quality development.

Secondly, the innovative “sports and education integration” model: open the cross-discipline of “sports digital technology” in colleges and universities to cultivate composite talents. Given the shortage of composite talents in the digital transformation of the sports industry, we should innovate the talent cultivation mode of “integration of sports and education”. Specific measures include the opening of “sports digital technology” interdisciplinary subjects in colleges and universities and the organic integration of sports science and computer science, data analysis, artificial intelligence, and another multidisciplinary knowledge. For example, colleges and universities can cooperate with sports enterprises and scientific research institutions to jointly design the curriculum and teaching content, which includes traditional sports courses such as sports event operation and management, sports training, and digital technology-related courses such as digital image processing, machine learning algorithms, and big data analysis technology. At the same time, it can also ensure that graduates can smoothly enter the sports industry for employment by setting up directional training programs and signing talent delivery agreements with sports enterprises to meet the industry's demand for composite talents. In addition, colleges and universities can also carry out relevant scientific research projects and practical activities to provide students with opportunities for practical exercise, cultivate their innovative ability and ability to solve practical problems, and provide solid talent support for the digital transformation of the sports industry.

5. Conclusion

The essence of the high-quality development of the digitally enabled sports industry is the reconfiguration of production relations triggered by the technological revolution. This

paper reveals that the digital transformation needs to break through the "single point of progress" thinking and establish a resonance mechanism of technological research, industrial synergy and institutional innovation. Future research should focus on two aspects: first, the definition of ownership and value assessment of virtual sports assets under the meta-universe scenario; and second, the game of the right to make rules of digital sports in the globalization competition. It is recommended to establish a national digital sports innovation center, set up an interdisciplinary research team, and continue to track the far-reaching impact of disruptive technologies such as blockchain and brain-computer interface on sports ethics and industrial patterns.

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